Semiconductor 1.7 W Volume Bragg Laser with Divergence Close to a Diffraction Limit

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Abstract: Novel volume Bragg laser (VOBLA) with two photo-thermo-refractive volume Bragg gratings feedback is studied on the basis of 150-μm-stripe LD. High-efficient, near diffraction-limited operation at power of 1.7W and spectral width of 250pm are demonstrated.

OCIS codes: (140.5960) Semiconductor lasers, (090.7330) Volume holographic gratings

The use of external resonators for improvement of spatial parameters of high power semiconductor lasers has been under intensive investigation for last 20 years. However, all desirable features such as diffraction limited divergence combined with high spectral brightness at high levels of pumping are not achieved yet [1-5]. The proposed solution of the problem is the use of an external cavity with two volume Bragg gratings for selection of a single transverse mode. Key elements for a considered construction are high-efficient volume Bragg gratings recorded in photo-thermo-refractive (PTR) glass [6, 7]. High-efficient transmitting volume Bragg gratings provide complete selection directly in space of wave vectors with very high angular selectivity while reflective Bragg gratings serve as feedback mirror with high spectral and angular selectivity. The used PTR Bragg gratings had absolute diffraction efficiency about 98% and were stable in high power laser beams and at elevated temperatures.

Optical design of volume Bragg laser used in this work is shown in Fig. 1. A 150-μm-stripe laser diode (LD) with antireflection (AR) coating at the front facet providing reflection ~ 0.5% was pumped by pulse current. Its radiation was collimated along the fast axis and was not collimated along the slow axis. As for wide-stripe LD dominant modes manifest off-axis emission with two main lobes, a transmitting Bragg grating was aligned in such way that diffracted maximum power from one of these lobes. The used transmitting Bragg grating with 98% diffraction efficiency had angular selectivity of 0.65 deg (FWHM). Such angular selectivity corresponds to near diffraction limited beam divergence for laser with 150-μm-stripe. A reflecting Bragg-grating with 98% diffraction efficiency reflected diffracted beam back to resonator and thereby provided necessary feedback. In other words we could select a single high-order mode of internal LD cavity within a wide range of pumping current. The first main lobe of this high-order mode was used for feedback. The second lobe did not interact with both Bragg gratings due to their narrow angular selectivity and was used as an output beam with near diffraction limited divergence. The total length of a proposed LD with an external cavity did not exceed 4-5 mm and was limited only by the used mechanical parts.

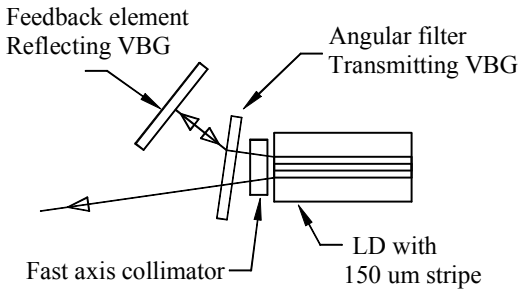

Fig.1 Semiconductor volume Bragg laser with a transmitting grating as an angular selective element and a reflecting grating as a feedback mirror with spectral and angular selectivity.

Feedback provided by the Bragg gratings resulted in narrowing of the angular divergence to the near diffraction limit with FWHM=0.6° (Fig. 2). Increasing of pumping up to 8 thresholds results in increasing of the background radiation but the single mode regime is controlled by PTR volume Bragg grating within the whole region of pumping. This increasing of spatial brightness is accompanied by significant narrowing of the spectral width down to 250 pm (Fig. 3).

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2004		**00-00-2004 to 00-00-2004**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Semiconductor 1.7 W Volume Bragg Laser with Divergence Close to a Diffraction Limit	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Central Florida,College of Optics & Photonics/CREOL,PO Box 162700,Orlando,FL,32816-2700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**2**	

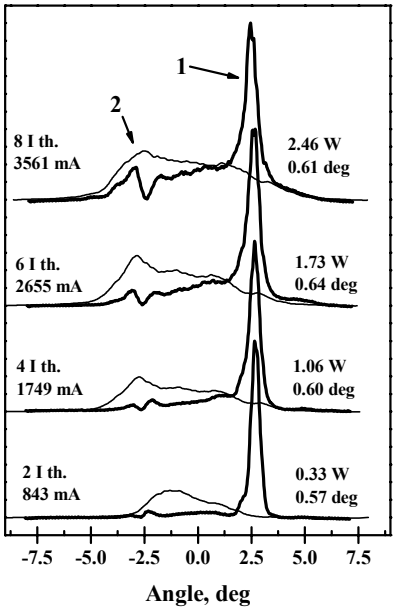

Fig. 2. Far field pattern for VOBLA (1) with the reflective grating and for free running LD (2).

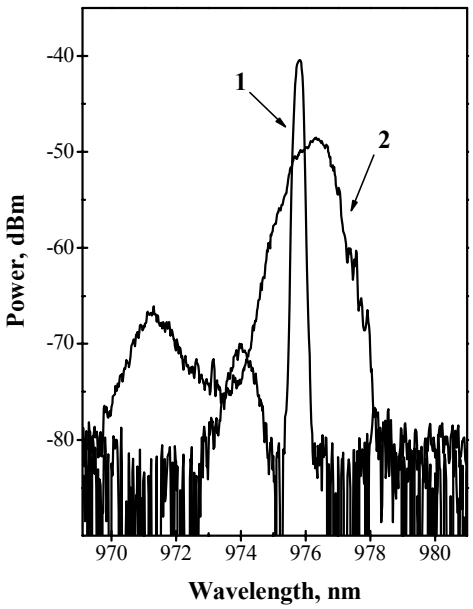

Fig. 3. Spectra of the semiconductor volume Bragg laser (1) and free running LD (2) at $8I_{th}$ pumping current (3561 mA).

Output power versus pumping current is shown in Fig. 4 for VOBLA and free running LD in the same arrangement with detuned Bragg grating (Fig. 1). The grating feedback reduced threshold current by 1.45 times to 370 mA. Slope efficiency for VOBLA (0.784 W/A) was 98% of that for the free running LD. Absolute reduction of slope efficiency for about 14% compare to that in an original LD (0.91 W/A) is caused by Fresnel reflection of the used transmitting PTR gratings that had no AR coating.

Thus, semiconductor VOBLA having simple and robust design, provides high power emission with near diffracted limited divergence, high-spectral brightness with efficiency close to that of the free running LD.

The work was supported by DARPA SHEDS program contract HR-01-1041-0004. Authors thanks Larissa Glebova, Ina Ciapurina, and Julien Lumeau for PTR glass preparing and certification.

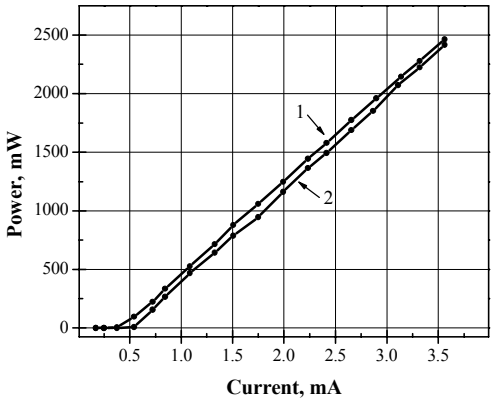

Fig. 4. Light-current charecteristic for the semiconductor volume Bragg laser (1) and the free running laser diode (2).

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